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(54) Ceramic arc tube

(57) A ceramic arc tube is described which uses a two piece arc tube design requiring only one hermetic joint. The arc tube is made in two sections (2,4) and joined using a lap joint. Because the arc tube body is made in two sections (2,4), each section (2,4) can be produced by conventional ceramic forming techniques.

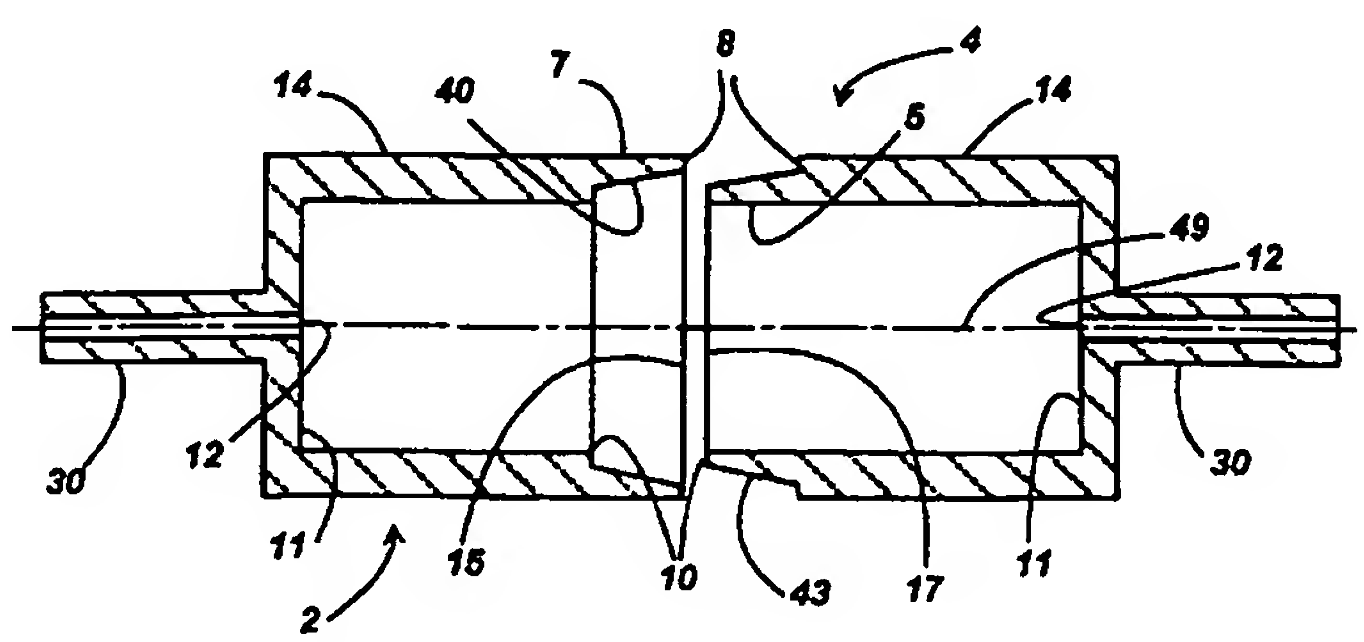

FIG. 3

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Description

TECHNICAL FIELD

[0001] This invention relates to ceramic arc tubes for high intensity discharge lamps. In particular, this invention relates to forming hermetic seals in ceramic arc tubes.

BACKGROUND ART

[0002] Ceramic arc tubes are used to contain the high temperature arcs of high intensity discharge (HID) lamps. General examples of ceramic arc tubes for HID lighting applications are shown in U.S. Patent Nos. 4,387,067, 4,999,145, and 4,799,601 which are incorporated herein by reference. Historically, these arc tubes were long cylindrical tubes, but recent lamp developments and the use of corrosive metal halide fill materials have dictated the use of more compact and complex shapes. For example, when a cylindrical geometry is used with a metal halide fill, the lamp fill tends to reside at the ends of the arc tube in the corner between the tube wall and the end button. During long term operation, these lamps are often characterized by corrosion of the ceramic in this area. The lamp ultimately fails when the corrosion breaches the arc tube wall allowing the fill gas to leak. Modifying the arc tube geometry to have hemispherical ends reduces the arc tube corrosion by eliminating the cold spot where the fill condenses. Not unexpectedly, the compact and complex arc tube shapes are more difficult to manufacture. In addition, if several parts are used in the arc tube assembly, greater effort is required to keep the parts aligned and obtain hermetic seals. Thus, it is also desirable to reduce number of parts and seals used to construct the arc tube.

[0003] Blow molding and gel casting can be used to form unitary arc tube bodies having the desired internal geometry but both methods have inherent disadvantages. Blow molded lamps are limited by the degree of expansion achievable during blowing and are characterized by a thinning of the arc tube wall. Gel casting is limited by the need to use a temporary core to define the cavity shape. The temporary core becomes entrapped inside the formed arc tube and must be removed. Typically, this is achieved by melting the core which is made of a low melting point material such as a wax. Because the core is destroyed by this process, gel casting tends to be a more expensive process. Additionally, the temporary core material can contaminate the arc tube cavity causing problems with lamp operation.

[0004] While it is possible to form a unitary arc tube body by blow molding or gel casting, current designs further require that two capillaries which contain and seal the electrodes be joined to the arc tube by interference sintering. This results in a three piece arc tube construction having two joints that must be hermetic after sintering.

SUMMARY OF THE INVENTION

[0005] It is an object of the invention to obviate the disadvantages of the prior art.

[0006] It is another object of the invention to provide a ceramic arc tube having a two piece construction.

[0007] It is a further object of the invention to provide a ceramic arc tube assembly which can be formed by conventional ceramic molding techniques.

[0008] In accordance with one aspect the invention, there is provided a ceramic arc tube comprising a hollow ceramic body having a wall, electrodes, male and female sections, and a cavity containing a fill material; the electrodes extending into the cavity through the wall and being connectable to an external source of electrical power; the male section being sealed hermetically to the female section by a lap joint; the lap joint having internal and external positioning interfaces and a sealing interface.

[0009] In accordance with another aspect of the invention, there is provided a ceramic arc tube assembly comprising male and female arc tube sections; each section being substantially hollow and having a wall and open and closed ends; the open ends having a sealing surface and internal and external positioning surfaces, the internal and external positioning surfaces being located at opposite ends of the sealing surface; the closed ends having an opening for receiving an electrode; the male and female sections when joined at the open ends forming a lap joint and enclosing a cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig 1. is a cross sectional view of a cylindrical arc tube assembly having cylindrical sealing surfaces.

Fig. 2 is a cross sectional view of an assembled arc tube having the configuration shown in Fig. 1.

Fig. 3 is a cross sectional view of a cylindrical arc tube assembly having frustoconical sealing surfaces.

Fig. 4 is a cross sectional view of an assembled arc tube having the configuration shown in Fig. 3.

Fig. 5 is a cross sectional view of another axially symmetric arc tube having frustoconical sealing surfaces.

Fig. 6 is a cross sectional view of an assembled arc tube having the configuration shown in Fig. 5.

DESCRIPTION OF THE INVENTION

[0011] For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims taken in conjunction with the above-described drawings.

[0012] The present invention uses a two piece arc tube design requiring only one hermetic joint. The arc tube is made in two sections and joined using a lap joint. Because the arc tube body is made in two sections, each section can be produced by conventional ceramic forming techniques such as isostatic pressing, injection molding, slip casting, or gel casting. If gel casting is used, a temporary core is not needed to form the internal contours of the arc tube because each section has an accessible open end. The lap joint is designed so that the two sections may be easily aligned and fitted together. Overlapping flanges are created on the open ends of each section. The flanges provide present surfaces for sealing and positioning the two sections. To maintain a tight seal, the sections may be designed with a slight interference fit. The amount of interference fit required to maintain a tight seal is typically 1 to 8%. Greater degrees of interference fit could be used but might lead to considerable distortion of the arc tube shape.

[0013] After the parts are formed and assembled, any organic binder in the green parts is removed. The assembled sections are presintered to tack bond them together and remove residual organic material. An alternative method of joining the two sections is to combine a temperature slightly above the softening or melting point of the organic binders used in the fabrication of the sections with a slight pressure to weld the two sections together prior to binder removal. In this manner, the degree of interference fit could be reduced or eliminated thereby reducing distortion of the sintered arc tube. The final sealing of the two sections is achieved by sintering the arc tube usually in a hydrogen containing atmosphere. The temperatures, heating rate, cooling rate and soak period at peak temperature will vary depending on the ceramic composition. Various arc tube and lap joint configurations are shown in Figs. 1-6.

[0014] Fig. 1 is a cross sectional view of an arc tube assembly having substantially hollow, cylindrical male 4 and female 2 sections. Each section has the same inside and outside diameters. At the closed end 11 of each section, there is an opening 12 in the wall 14 for inserting an electrode (not shown). Capillaries 30 are attached at the closed ends 11 to facilitate positioning and sealing of the electrode in the completed arc tube. At open ends 15 and 17, the sections have internal 10 and external 8 positioning surfaces and sealing surfaces 3 and 6. These surfaces conjoin to form the lap joint shown in Fig. 2. More particularly, flange 5 of male section 4 extends coaxially at the periphery of open end 17. The outside diameter of flange 5 is less than the outside diameter of the male section. Sealing surface 3 is cylindrical and is formed by the outside diameter of flange 5. Similarly, flange 7 of female section 2 extends coaxially at the periphery of open end 15. Flange 7 has an inside diameter which is greater than the inside diameter of female section 2 and equal to the outside diameter of flange 5. Sealing surface 6 is cylindrical and is formed by the inside diameter of flange 7. The recess formed at the open end 15 accepts flange 5 of the male section when the parts are mated to form the arc tube. Positioning surfaces 8 and 10 are formed by the discontinuities in the diameters of each section 2 and 4 at their open ends. Positioning surfaces 8 and 10 ensure proper mating of the two sections. Preferably, positioning surfaces 8 and 10 are substantially orthogonal to the central axis of sections 2 and 4 however other configurations are possible.

[0015] In the embodiment shown in Fig. 1, sealing surfaces 3 and 6 are cylindrical and coaxial with the central axis of the two sections. However, in other embodiments, one or both of the sealing surfaces may be slightly tapered. For example, when an interference fit is desired, the outside diameter of flange 5 is made slightly larger than the inside diameter of flange 7 and sealing surface 3 of male section 4 is tapered inwardly. Hermetic seals have been obtained using a 1% interference fit (0.004 inches) and a 2° taper on the male flange. Similar performance was observed when the interference fit cut in half to 0.002 inches.

[0016] The arc tube sections are made preferably from alumina which provides the necessary degree of translucency after sintering. A preferred composition is a pure alumina containing about 500 ppm MgO. After forming and assembling the parts, the assembled sections are presintered in air at below 1350°C, and preferably at 1200°C for 1 hour. Final sintering is performed in a hydrogen containing atmosphere at a temperature from about 1820°C to 1950°C. More preferably, the arc tube parts are sintered in wet H_2 at 1935°C for 4 hours. In addition to forming hermetic seals, the sintered arc tubes of the present invention exhibit excellent dimensional control and reproducibility.

[0017] Fig. 2 is a cross sectional view of an assembled arc tube having the configuration shown in Fig. 1. Male section 4 has been mated to female section 2 and sintered to form a hermetic seal at lap joint 25. Lap joint 25 is composed of sealing interface 28 and positioning interfaces 22 and 24. The sealing and positioning interfaces in the assembled arc tube are formed at the junction of the sealing and positioning surfaces shown in Fig. 1. A hermetic seal is formed at the sealing interface 28 after final sintering. The general placement of sealing interface 28 is midway through arc tube wall 14. However, the relative thickness of flanges 5 and 7 may be adjusted to effect the formation of the sealing interface at different depths in wall 14. It is preferred that the width of sealing interface 28 be at least equal to half the thickness of the wall 14 in the region immediately adja-

cent to the lap joint. Hermetic seals may also be formed at the positioning interfaces 22 and 24. However, depending on the lap joint configuration, gaps may form at the positioning interfaces after sintering. In this embodiment, these gaps may extend up to halfway through the arc tube wall but have not been shown to affect lamp performance. The interior gap can be eliminated by making the male flange 0.001 to 0.005 inches longer than the female flange.

[0018] Electrodes 20 are sealed hermetically into capillaries 30 by a glass frit. The electrodes extend into cavity 32 and are connectable to an external source of electrical power such as a ballast. The cavity 32 contains fill 35 and a fill gas (not shown). The fill 32 may consist of any number of known arc tube fill materials and fill gases.

[0019] Fig. 3 and 4 are cross sectional views of an arc tube assembly and resultant arc tube similar to those shown in Figs. 1 and 2. Flanges 5 and 7 are tapered with respect to central axis 49 to give sealing surfaces 40 and 43 and sealing interface 42 a frustoconical shape. The taper angle formed by frustoconical sealing surfaces 40 and 43 and central axis 49 may varied from 5 to 20 degrees. The limit on the taper angle is the angle beyond which a good diffusion bond seal can be achieved. If the angle is too steep, the driving force for bonding using an interference seal would be reduced to a point where sections 2 and 4 would separate during sealing by sliding along the sealing interface 42 instead of joining. The frustoconical shape can provide a wider sealing interface than the cylindrical shape and tends to reduce the formation and penetration of gaps at positioning interfaces 22 and 24. This is believed to increase the strength of the lap joint 47.

[0020] Fig. 5 and 6 illustrates an embodiment of the present invention in which the arc tube shape is not a right cylinder but still remains axially symmetric about central axis 49. In this embodiment, closed ends 11 have a rounded, hemispherical geometry. As previously explained, the rounded contour reduces corrosion of the arc tube wall caused by the condensation of fill 35. Lap joint 47 is the same as the lap joint shown in Figs. 3 and 4.

[0021] While there has been shown and described what are at the present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

Claims

1. A ceramic arc tube comprising:

   a hollow ceramic body having a wall, electrodes, male and female sections, and a cavity containing a fill material; the electrodes extending into the cavity through the wall and being connectable to an external source of electrical power; the male section being sealed hermetically to the female section by a lap joint; the lap joint having internal and external positioning interfaces and a sealing interface.

2. The ceramic arc tube of claim 1 wherein the ceramic body and sealing interface are symmetric about a central axis.

3. The ceramic arc tube of claim 2 wherein the sealing interface is frustoconical.

4. The ceramic arc tube of claim 3 wherein the sealing interface is cylindrical.

5. The ceramic arc tube of claim 2 wherein the internal and external positioning interfaces are orthogonal to the central axis.

6. The ceramic arc tube of claim 3 wherein the sealing interface has a taper angle of between 5 and 20 degrees.

7. The ceramic arc tube of claim 1 wherein the width of the sealing interface is at least equal to half of the thickness of the arc tube wall in a region immediately adjacent the lap joint.

8. A ceramic arc tube assembly comprising: male and female arc tube sections; each section being substantially hollow and having a wall and open and closed ends; the open ends having a sealing surface and internal and external positioning surfaces, the internal and external positioning surfaces being located at opposite ends of the sealing surface; the closed ends having an opening for receiving an electrode; the male and female sections when joined at the open ends forming a lap joint and enclosing a cavity.

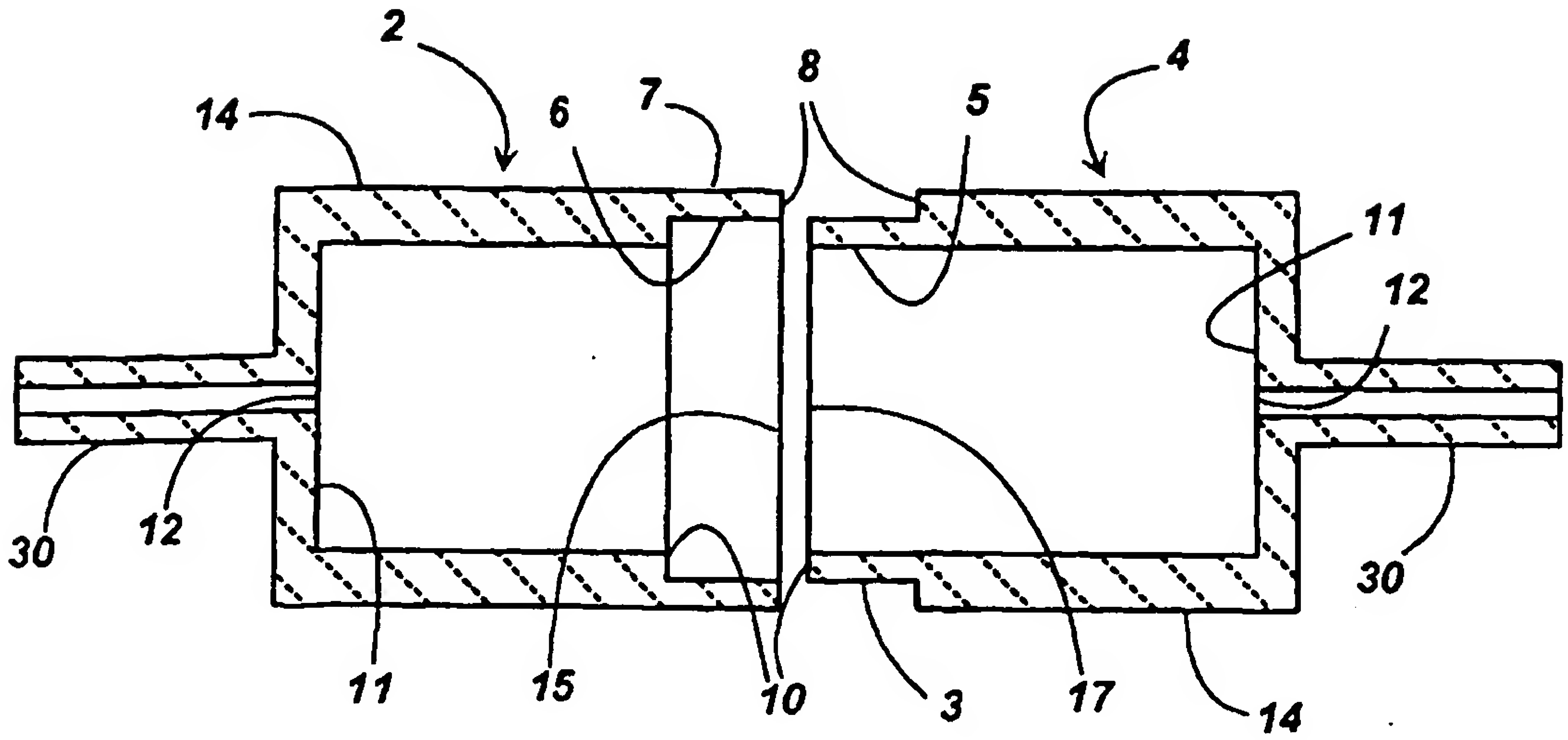

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FIG. 1

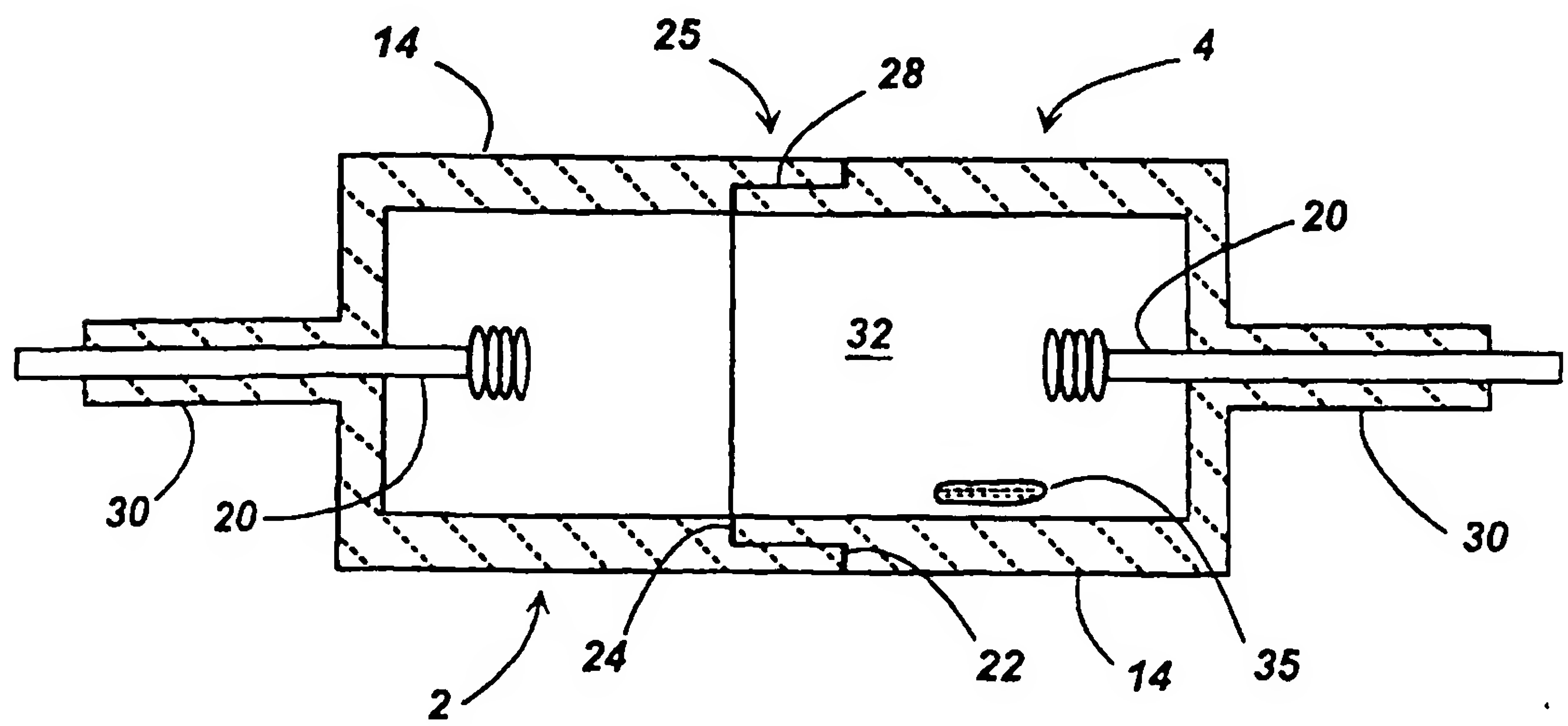

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FIG. 2

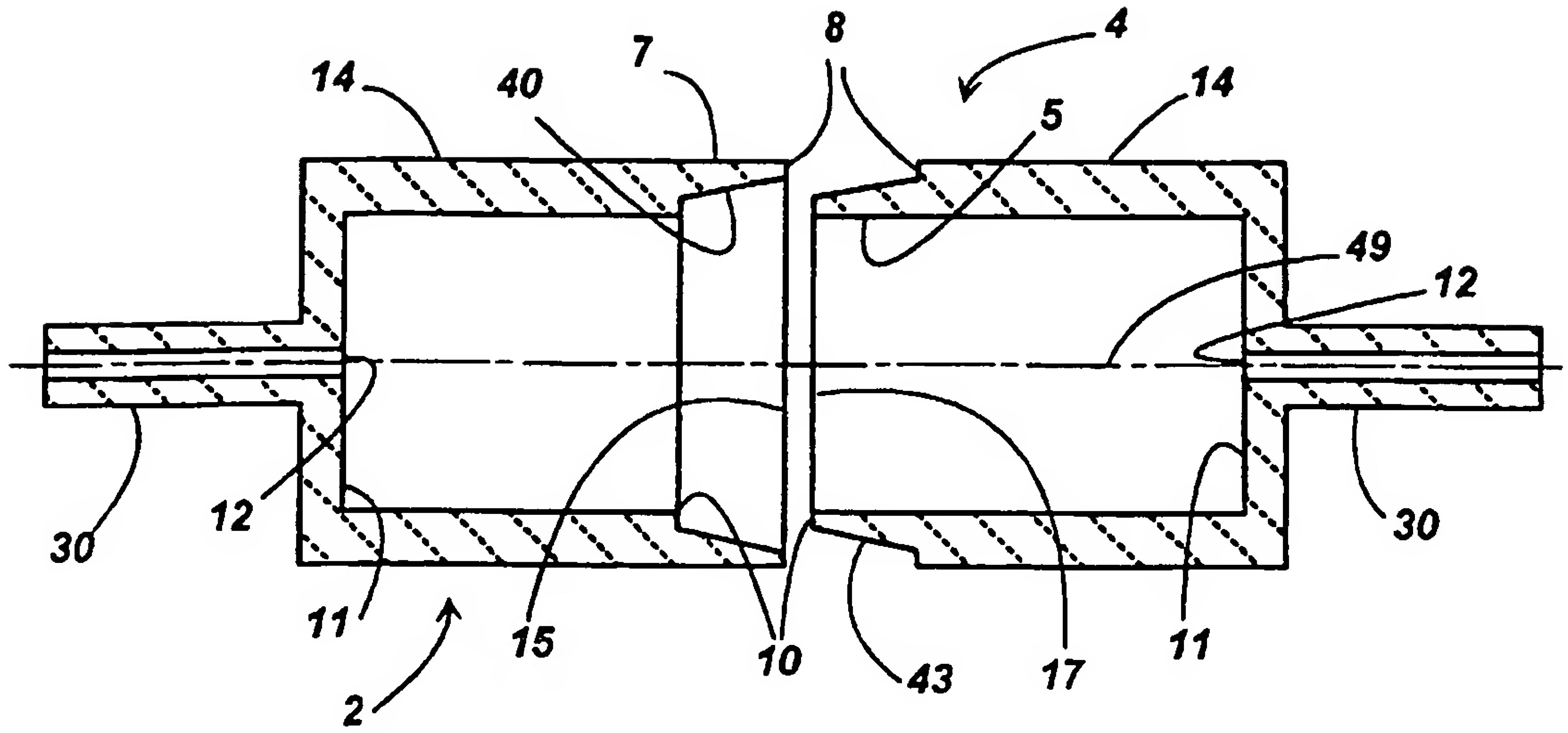
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FIG. 3

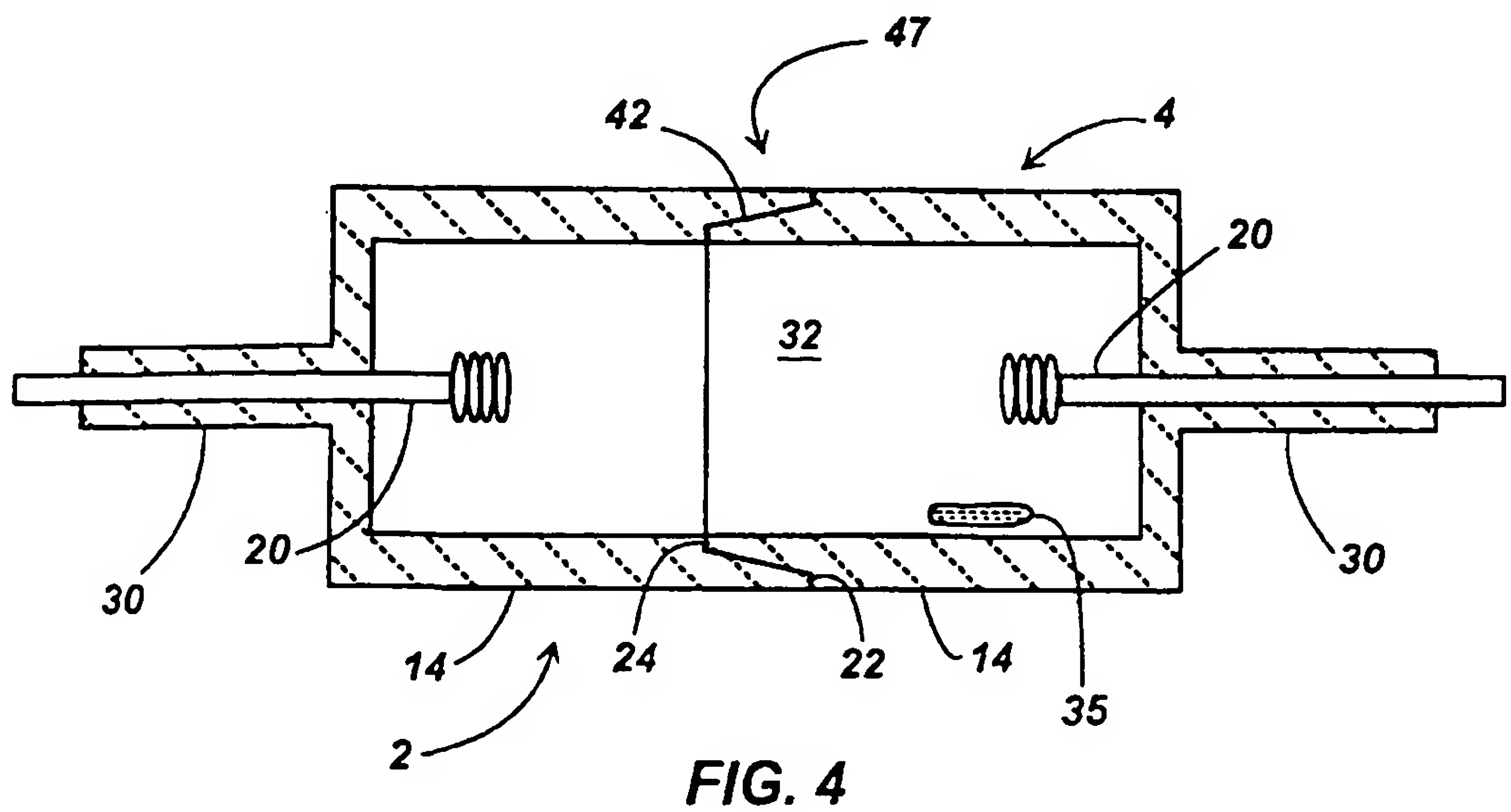
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FIG. 4

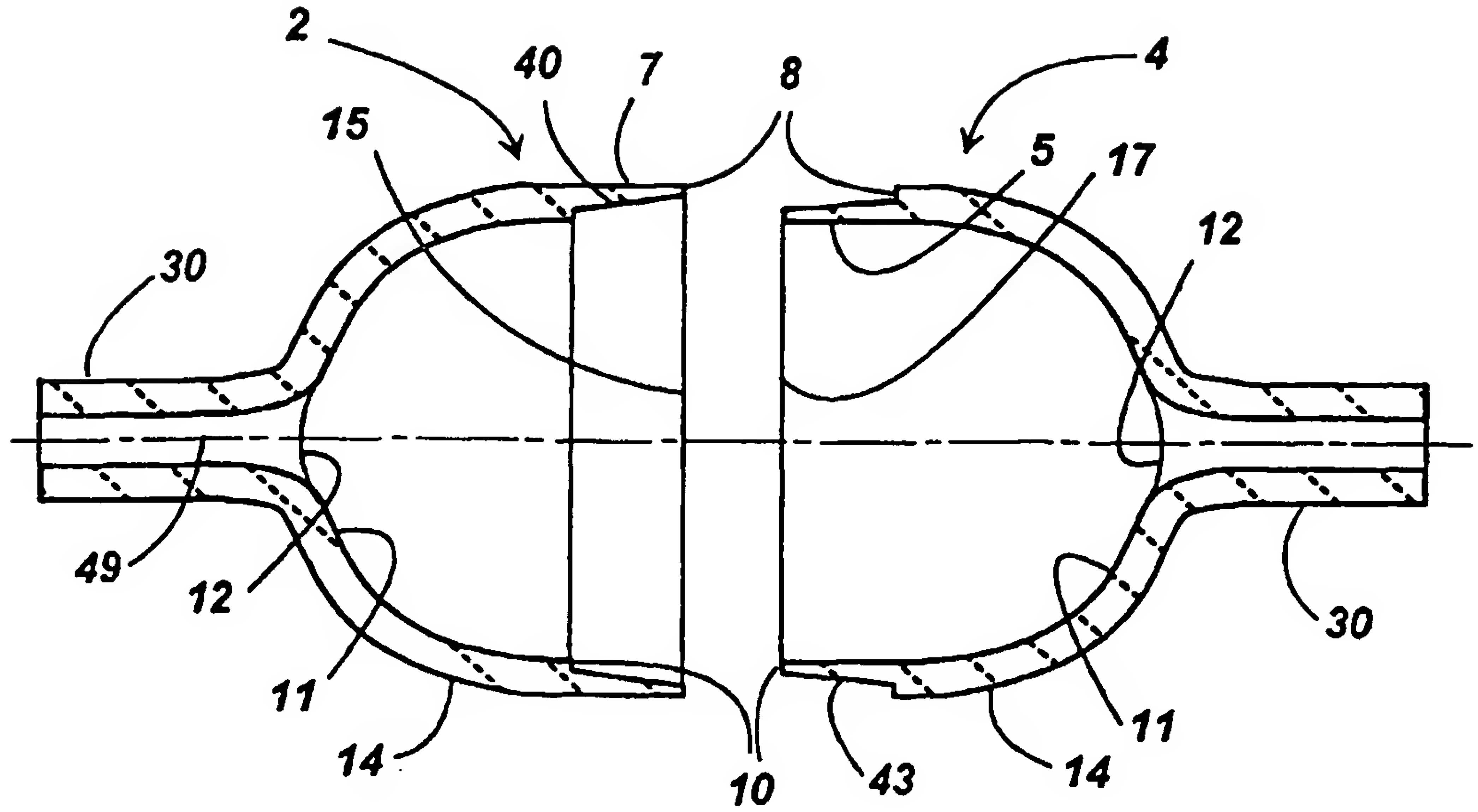
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FIG. 5

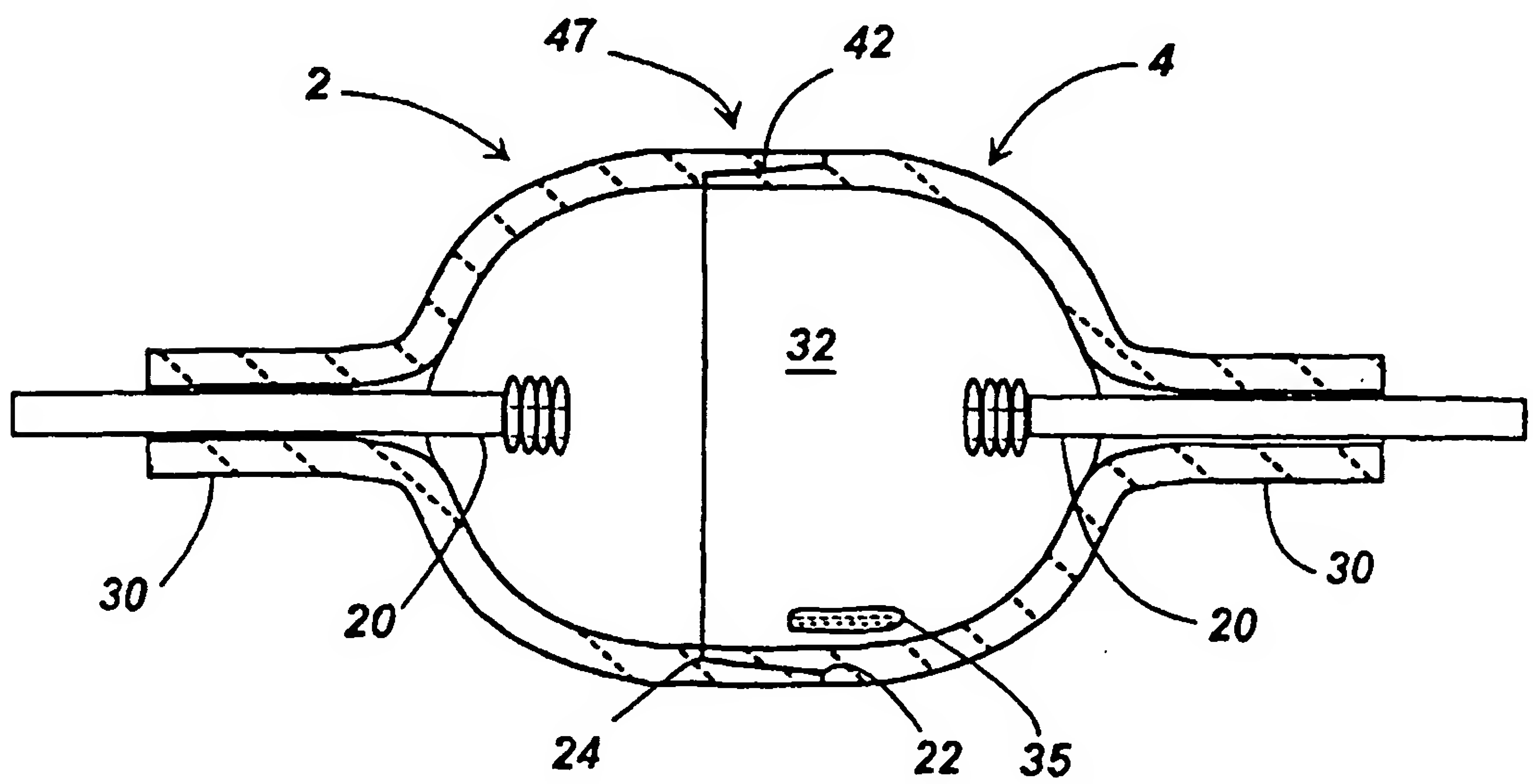
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FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 11 9008

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,A	US 4 387 067 A (KOBAYASHI KAZUO ET AL) 7 June 1983 (1983-06-07) * abstract; figures 2,4-7 * * column 1, line 7 - line 15 * * column 6, line 3 - line 38 * -----	1,8	H01J61/36

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H01J
H01K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 January 2001	Martin Vicente, M

CATEGORY OF CITED DOCUMENTS

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